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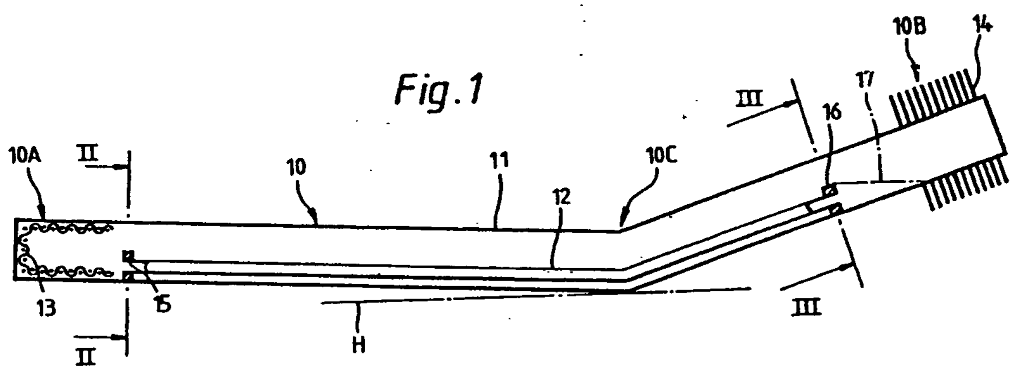
(54) Heat pipes

(57) The starting ability of a heat pipe, having an inner tube (12) separating the vapour-phase and liquid-phase return paths from one another, under "negative slope" conditions, i.e. with the heat pipe extending (slightly) upwardly towards its heat-absorbing end (10A), is improved by providing not only a bend (10C) so that a part of the heat pipe also extends upwardly towards the heat-releasing end (10B) but also a pair of weirs (15, 16) through which the respective ends of the inner tube (relatively small-bore, and providing the liquid-phase return path) open to the two ends of the heat pipe, the top of the weir at the heat-releasing end being higher (in space) than that at the heat-absorbing end.

Fig. 1



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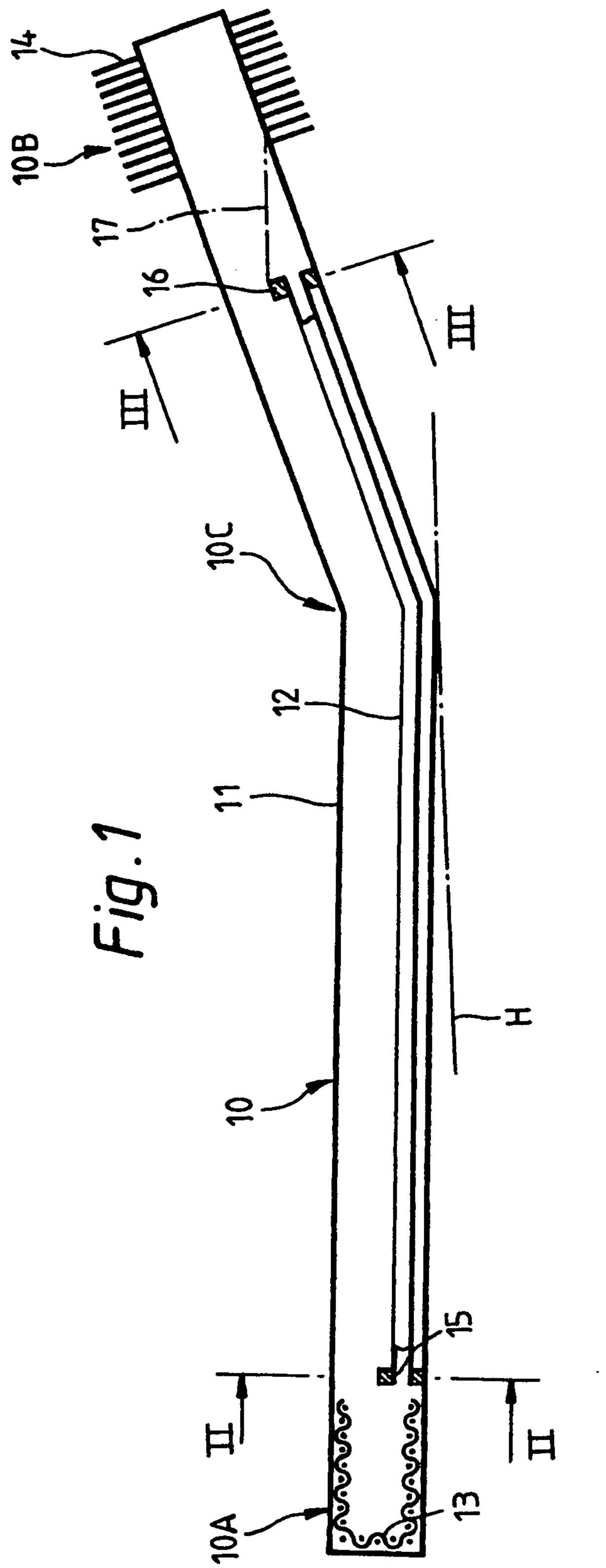

Fig.1

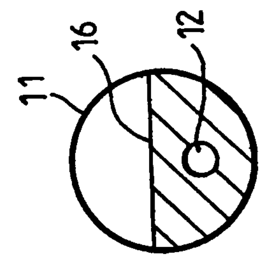

Fig.3

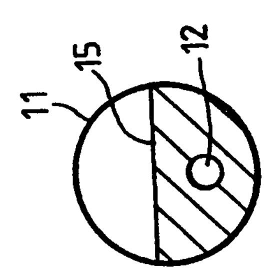

Fig.2

SPECIFICATION
Heat pipes

This invention relates to heat pipes.

The performance of a conventional wicked heat pipe is quite seriously reduced if the direction in which it is required to convey heat away from a heat source has a downward component in the immediate vicinity of the heat source, i.e. if the heat-absorbing end of the heat pipe is required to operate in what may be called "negative slope" conditions.

It has been proposed, for ensuring that liquid-phase working fluid will be always available at the heat-absorbing end of the heat pipe even under negative-slope conditions, to provide a bend in the heat pipe so that it can be installed with the bend below both the heat-absorbing end and its other, heat-releasing end and so that, even if the part of the heat pipe between the bend and the heat-absorbing end is unavoidably subject to negative-slope conditions, the heat-releasing end may nevertheless be at a greater height than the heat-absorbing end and working fluid in the liquid-phase (assuming it is present in sufficient quantity) will always be available in adequate quantity at the heat-absorbing end. It has further been proposed, in order to improve the performance of such a heat pipe when operating under negative-slope conditions, to segregate the intended paths of liquid to the heat-absorbing end and of vapour away therefrom, and specifically to provide, within an outer tube (sealed at both ends) of the heat pipe, an open-ended inner tube extending within the outer tube and having its ends opening respectively into the interiors of the respective closed ends of the outer tube, with the interior of the inner tube providing the intended path for vapour from the heat-absorbing end to the heat-releasing end and the generally annular space within the outer tube but outside the inner tube constituting the return path for working fluid in the liquid phase.

A heat pipe in accordance with the above-described proposals can, once started, operate quite efficiently in negative-slope conditions; but in the absence of a sufficient heat supply at its heat-absorbing end to maintain it in operation it is subject to flooding of both the inner and outer tubes at that end with liquid-phase working fluid, and it can be difficult to start again when the supply of heat is resumed. Restarting involves expelling liquid working fluid, by means of working fluid transformed by the heat to the vapour phase, from the intended vapour-phase path, and it has further been proposed, with a view to facilitating this, to provide a reservoir, communicating with the interior of the heat pipe, to accommodate what would otherwise be an excess of liquid working fluid once ordinary operating conditions have been established and the intended vapour-phase path has been cleared of liquid working fluid. It may be remarked, however, that this prior proposal of a reservoir contemplated connecting it to the interior of the outer tube of a heat pipe in which the interior of an inner tube, as mentioned above, would provide the intended vapour-phase path: thus the proposal was to connect the reservoir to the intended liquid-phase path and not directly to receive liquid from the intended vapour-phase path.

Even the above-mentioned proposals for segregation of the vapour-phase and liquid-phase fluid paths and for provision of a liquid-phase reservoir do not lead to a heat pipe which can be relied upon to start dependably under negative-slope conditions; and it is an object of the present invention to provide an improved heat pipe with enhanced starting reliability under negative-slope conditions.

According to the invention, a heat pipe comprises a sealed outer tube with a bend intermediate its ends so that its ends, constituting respectively a heat-absorbing and a heat-releasing end, can both be higher than the bend, and, within the outer tube, an inner tube having one end opening to the interior of the heat-absorbing end of the outer tube through a first weir and having a second end between the said bend and the heat-releasing end of the heat pipe and opening towards the latter through a second weir, the configuration of the heat pipe being such that even with its heat-absorbing end installed in negative slope conditions the second weir is higher than the first weir and liquid-phase working fluid trapped above the second weir will tend to flow through the inner tube towards the heat-absorbing end of the heat pipe.

The invention will be more fully understood from the following description of an embodiment thereof with reference to the accompanying drawings, in which:—

Figure 1 is a schematic longitudinal vertical sectional view of a heat pipe according to the invention;

Figure 2 is a sectional view, on a larger scale, on the line II—II of Figure 1; and

Figure 3 is a sectional view, on the scale of Figure 2, on the line III—III of Figure 1.

The illustrated heat pipe 10 comprises an outer tube 11 with sealed ends and, within the tube 11, a relatively small-bore tube 12 which is open at both ends. One end of the heat pipe, a heat-absorbing end 10A, is provided within the tube 11 with a wicked evaporator 13 and the other end, a heat-releasing end 10B, has fins 14 mounted externally on the tube 11 to facilitate the dissipation of heat therefrom. Between its ends 10A and 10B, the heat pipe has a bend 10C at which both the tubes 11 and 12 are bent correspondingly, so that (as illustrated) both parts of the heat pipe may be inclined to the horizontal H and so that, even with the heat-absorbing end 10A thus subjected to negative slope conditions, the heat-releasing end 10B may be at a greater height than the heat-absorbing end 10A. It should, perhaps, be stated that in practice the slopes of the parts of the heat pipe might be less than Figure 1 suggests. For example, the distance of the heat-absorbing end 10A from the bend 10C

may be three or four metres, and the negative-slope conditions may arise only because this part of the heat pipe, though nominally horizontal, has been inaccurately installed (either inadvertently or unavoidably) to such an extent that the end 10A is a few centimetres (say one or two times the diameter of the heat pipe) higher than the bend 10C.

In order to avoid starting difficulties in such conditions, the illustrated heat pipe is provided with a weir 15 close to its heat-absorbing end 10A and one end of the tube 12 opens through this weir 15 to the interior of the tube 11 at the end 10A; and, further, a second weir 16 is provided near the end 10B of the heat pipe, and the other end of the tube 12 opens through the weir 16 to the interior of the tube 11 at the end 10B. The configuration of the heat pipe is such that, even if its heat-absorbing end 10A is subject to negative-slope conditions, the weir 16 is at a greater height than the weir 15. Consequently any liquid-phase working fluid trapped above the weir 16 (as suggested by a liquid surface 17 in Figure 1) will tend to flow through the tube 12 and escape to the interior of the heat-absorbing end 10A of the heat pipe. Even if most of it then escapes over the weir 15 into the space between tubes 11 and 12 in the region of the bend 10C, some will be trapped by the weir 15 and held in contact with the wick 13 ready to be vaporised when heat is applied to the end 10A. In view of the relatively small bore of the tube 12 and its disposition, preferably, in the lower part of the tube 11 at the bend 10C, the increasingly large vapour bubble which is generated on heat being applied to the end 10A clears the interior of the tube 11 in preference to that of the tube 12. Accordingly, in the heat pipe according to this invention, the space between the tubes 11 and 12 constitutes the vapour path by which vapour generated at the heat-absorbing end 10A travels to the heat-releasing end 10B. On being cooled at the end 10B, the vapour re-condenses to liquid which then is trapped above the weir 16; and the interior of the tube 12 constitutes the return flow path for the liquid-phase working fluid (which may be water under sub-atmospheric pressure).

CLAIMS

1. A heat pipe comprising a sealed outer tube with a bend intermediate its ends so that its ends, constituting respectively a heat-absorbing end and a heat-releasing end, can both be higher than the bend, and, within the outer tube, an inner tube having one end opening to the interior of the heat-absorbing end of the outer tube and having a second end between the said bend and the heat-releasing end of the outer tube and opening towards the latter, wherein the one end of the inner tube opens to the interior of the heat-absorbing end of the outer tube through a first weir and the second end of the inner tube opens towards the heat-releasing end of the outer tube through a second weir, the configuration of the heat pipe being such that even with its heat-absorbing end installed in negative slope conditions the second weir is higher than the first weir and liquid-phase working fluid trapped above the second weir will tend to flow through the inner tube towards the heat-absorbing end of the heat pipe.

2. A heat pipe as claimed in Claim 1, wherein the inner tube is of narrow bore, compared with the outer tube.

3. A heat pipe as claimed in Claim 2, wherein, with the heat pipe disposed with its bend below its ends, the inner tube is disposed, at the bend, in the lower part of the outer tube.

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